TITLE: SAMPLING, ANALYSIS, AND PROPERTIES OF PRIMARY PM-2.5: APPLICATION TO COAL-FIRED UTILITY BOILERS

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ABSTRACT

OBJECTIVES

This project involves the design and construction of a state-of-the-art dilution sampler to investigate PM-2.5 (particulate matter with an aerodynamic diameter less than 2.5 μm) emissions from a pilot scale pulverized coal combustor. This sampler simulates the dilution and cooling processes that occur when the hot combustion products leave the stack. The goal is to provide a more basic understanding of the emissions of PM-2.5 from coal-based power generation systems. Four specific tasks have been defined:

1. Design, construction and evaluation of a portable state-of-the-art dilution sampler for the characterization of $PM_{2.5}$ emissions from stationary combustion sources.

2. Emission testing will be performed with the dilution sampler installed on the slipstream of a pilot-scale pulverized coal combustor located at the Pittsburgh site of the National Energy Technology Laboratory.

3. Experiments will be conducted to determine PM-2.5 emissions from the pilot-scale combustor as a function of dilution rate, temperature, and relative humidity. Samples will be analyzed to determine the basic size distribution and composition of emissions, emission rates of nanoparticles and elemental and organic carbon, and the hydrophilic properties of the particles.

4. Development of dilution sampling methodology for coal-fired power plants based on results from Task 3.

ACCOMPLISHMENTS TO DATE

Work during the first year of the project has focused on the design, construction, and evaluation of the dilution sampler. The design requirements of the system are to allow independent variation of the dilution ratio, mixing rate, and residence time to allow examination of the effect of these parameters on sampling. Based on a detailed review of the dilution sampler literature, a prototype dilution tunnel was constructed to test a variety of design concepts and evaluate different modes of operation. Experiments were performed to evaluate mixing and particle loss as a function of tunnel geometry, flow rate, and mixing enhancement device. Experiments were also performed to evaluate operational issues involved with balancing flow rates in the tunnel and through the sample inlet. Based on the results from these tests, we have finalized the design of the dilution sampler; construction is underway and is expected to be completed early June of 2000.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAMS

In July 1997, the EPA issued new particulate matter standards that targeted the mass of particles smaller than 2.5 micrometers (PM-2.5). Emissions from coal-fired power plants and other combustion sources are significant contributors to ambient PM-2.5. Coal-fired power plants emit little primary PM, but are the dominant source of SO_2 and a major source of NO_x -- both important precursors of secondary fine particulate matter. EPA estimated annual identifiable control costs corresponding to the partial attainment of the selected PM standard to be $8.6 billion per year, based on the analysis of five major emitting sectors, one of which is coal-based power plants. Design of cost-effective PM control strategies is limited by the lack of understanding of the difficulty of establishing the PM source-receptor relationships. This project aims to improve our basic knowledge of PM-2.5 emissions from coal-based power systems.

PLANS FOR THE COMING YEAR

During the summer of 2000, the dilution sampler will be installed on a slipstream of the Combustion and Environmental Research Facility (CERF) at the National Energy Technology Laboratory (NETL). Experiments will be focused on examining the effect of sampling conditions on emission rates. Measurements will include particle number size distribution between 3 nm and 10 μm, PM-2.5 mass, and basic PM-2.5 speciation (water soluble ions, metals, OC/EC) as a function of sampling conditions. Results from these experiments will be presented at the American Association of Aerosol Research annual meeting in November. After a thorough evaluation of effects of sampling on PM-2.5 emissions, experiments will be performed to evaluate the effects of different operational modes (variations in coal quality, burner configuration, etc.) on emissions.